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XVIII
THE OPHIURANS OF MONTEREY BAY¹

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I. INTRODUCTION

Very little work has been done on the ophiurans of California. McClendon (1909) published a résumé of the species of the San Diego region. H. L. Clark (1911), in his fine paper on the North Pacific Ophiurans, included many species which occur in California. Busch (1918-1921) listed the species of Friday Harbor, Washington. Species described in all three of these papers occur in Monterey Bay. Outside of them, however, excluding a few occasional papers in which species from this locality are listed or described indirectly, no study has ever been made of the ophiurans of Monterey Bay. This bay is peculiarly situated in that here species representative of both the north and the south are found.

The present paper is based on (1) the collections made by the U. S. Fisheries Steamer Albatross in Monterey Bay in 1904; (2) specimens collected at divers times and by different persons working at the Hopkins Marine Station of Stanford University; and (3) specimens collected by the writer in the summer of 1921.

Of the 24 species which have been collected in Monterey Bay, seven are intertidal, while 17 have been secured only

¹Contribution from the Hopkins Marine Station of Stanford University.

from dredgings. Of the seven littoral species, only two have never been collected beyond the low tide level.

The 23 identified species are grouped into 15 genera, and eight families. The keys are artificial, and apply only to the species in Monterey Bay.

As the average collector will most likely come in contact only with the intertidal species, a key is given by which those forms which occur above the low tide level can be identified. The key is artificial and applies only to the littoral species.

The coloration of the living animals is given whenever possible. That of the intertidal species was made by the writer, and that of the dredged forms by Dr. W. K. Fisher, who accompanied the Albatross on her 1904 cruise.²

Alphabetical List of the Ophiurans of Monterey Bay

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|-------------------------------------|--|
| 1. <i>Amphiliamna pentacantha</i> | 13. <i>Ophiotden culveri</i> |
| 2. <i>Amphiodia occidentalis</i> | 14. <i>Ophiotden hastatum</i> |
| 3. <i>Amphiodia periercta</i> | 15. <i>Ophionereis eurybrachyplax</i> |
| 4. <i>Amphiodia urtica</i> | 16. <i>Ophionereis</i> sp. (young) |
| 5. <i>Amphiopholis pugetana</i> | 17. <i>Ophiopholis aculeata</i> forma <i>kennerlyi</i> |
| 6. <i>Amphiura arcyclata</i> | 18. <i>Ophiopholis bakeri</i> |
| 7. <i>Amphiura seminuda</i> | 19. <i>Ophiopholis longispina</i> |
| 8. <i>Asteroschema sublaeve</i> | 20. <i>Ophioplocus esmarki</i> |
| 9. <i>Asteronyx loveni</i> | 21. <i>Ophiopteris papillosa</i> |
| 10. <i>Gorgonocephalus eucnemis</i> | 22. <i>Ophiothrix spiculata</i> |
| 11. <i>Ophiacantha diplasia</i> | 23. <i>Ophiura leptoctenia</i> |
| 12. <i>Ophiacantha carypoma</i> | 24. <i>Ophiura lukenii</i> |

ECOLOGY OF THE LITTORAL FORMS

Due no doubt to the extreme fragility of ophiurans, the littoral forms are only found in well sheltered spots, where they are protected from the full impact of the waves by rock formations. The species, furthermore, segregate themselves in particular ecological surroundings.

²Dr. Fisher used Ridgway's (1886) Nomenclature of Colors, while the writer had the improved (1912) Color Standards and Nomenclature.

I take great pleasure in expressing my gratitude to Dr. W. K. Fisher who suggested this study to me, and under whose guidance the work was carried on, and to Dr. H. L. Clark, who kindly went over the manuscript and suggested some changes, while allowing me full access to the rich collection of ophiurans in the Museum of Comparative Zoology at Cambridge, Massachusetts.

A set of specimens will be deposited in the California Academy of Sciences' collection.

Ophiopteris papillosa is found under rocks, on a rocky base, pretty well out on the low tide level. It is the most active of the littoral forms, scampering away very quickly when its protecting rock is overturned. It possesses a remarkable power of autotomy, and will break its arms at their base very readily. Specimens are usually found together. Two or three may be under the same rock. It is fairly common.

Ophiopholis aculeata forma *kennerlyi* is found in about the same situations as *Ophiopteris*. It is much less active, and makes only slow movements when uncovered. I have never seen one break its arms, and it seems to be unusually lacking in the power of autotomy. It is a rather uncommon species.

Ophiothrix spiculata is found under rocks on a rocky bottom or on some alga, such as *Ulva*, in very secluded spots. When on *Ulva*, it seems to lie perfectly inactive, and lets itself be moved by the "va et vient" of the water. It shows remarkable diversity in its coloring. When much disturbed it breaks its arms occasionally, usually at the base. Although not as active as *Ophiopteris*, it will try to escape when annoyed. It is rather common.

Ophioplocus esmarki is found under flat rocks, on a rocky or sandy bottom. It is very sluggish, much more so than *Ophiopholis*. When disturbed, it simply lies in the same position, moving only the tips of the arms. It is fairly common.

Amphiodia occidentalis always is found on or in sand, under rocks, under broken *Mytilus* shells, or in the roots of *Phyllospadix*. Many specimens are usually found together, often in great numbers, and many times associated with *Amphipholis pugetana*. One may get many specimens by digging under rocks, in the sand. One finds *Amphiodia* a few inches below the surface of the sand, and many times one or several of its arms may project to the outside. It is fairly active, but moves its very long arms in an aimless way. This species is extremely common, and, due to its being protected by the sand, may be found in situations where no other ophiurans exist.

Amphipholis pugetana is found on *Ulva*, in *Macrocystis* holdfasts, among the roots of *Phyllospadix*, and under rocks

on sandy and rocky bottom. It never digs below the surface of the sand like *Amphiodia*. It is constantly in motion, but rather slowly. It is exceedingly common, and is perhaps the most abundant littoral form.

I found one young *Ophionereis* under a rock, on sandy bottom, at low tide. It was not very active, but made slow movements of the arms. This was the only representative of the species which I collected.

ECOLOGICAL TABLE

On Ulva—*Ophiotrix*, *Amphipholis*

In roots of *Phyllospadix*—*Amphipholis*, *Amphiodia*

In *Macrocystis* holdfasts—*Amphipholis*, *Amphiodia*

On sand—*Amphipholis*, *Amphiodia*

Under rocks

a. On rocky bottom—*Ophiopoteris*, *Ophiopholis*, *Ophiotrix*, *Ophioplocus*, *Amphipholis*.

b. On sandy bottom—*Ophioplocus*, *Ophionereis*, *Amphiodia*, *Amphipholis*.

In sand—*Amphiodia*

Ophioplocus esmarki and the young *Ophionereis* are the only species that have not been collected beyond the low tide level.

EXPLANATION OF TERMS

Adoral plates.	Two plates at the base of the jaws, proximal to the oral shield.
Arm comb.	A series of small scales on the upper side of the arm, distal to the disk, as in the genus <i>Ophiura</i> .
Arm spines.	Spines borne on the side arm plates (fig. 1, <i>u. s.</i>).
Dental papillæ.	Small projections under the teeth, at apex of jaw.
Disk.	The body as distinguished from the arms, especially the aboral side.
Distal.	Away from the mouth.
Genital slit.	The openings of the genital bursæ, at the sides of the arms, in the interbranchial areas.
Genital scales.	Scales bordering the genital slits.
Jaws.	The five triangular bodies which surround the mouth, each made up of several plates, and bearing the dental and oral papillæ.
Interbranchial areas. . .	The disk as differentiated from the arms on the oral side.
Oral papillæ.	Tooth-like projections on the sides of the jaws.

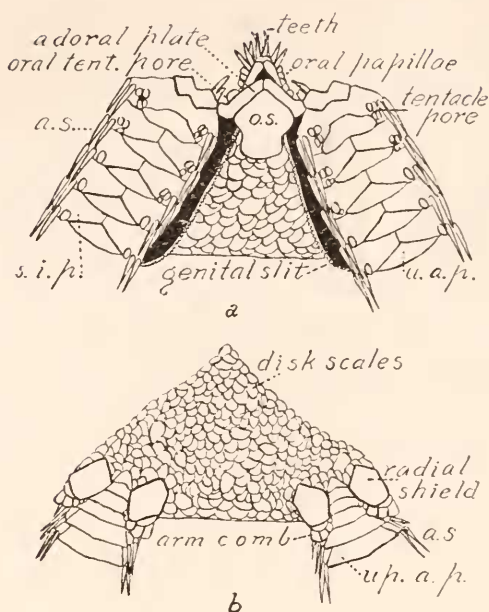


Fig. 1. *Ophiura lütkenii*, X3.2.—a, from below; b, from above. A. s, arm spines; o. s., oral shield; s. i. p., side arm plates; u. a. p. and up. a. p., under and upper arm plates.

- Oral shield..... Large plates, lying between the arms, singly, distal to the mouth (fig. 1, o. s.).
- Primary plates..... 1 dorso-central, 5 radial, 5 interrational plates, distinguished by their greater size, arranged symmetrically on aboral side of disk, but often distinguishable in adults.
- Proximal..... Towards the mouth.
- Radial shields..... Two large plates, at base of each arm on aboral side of disk. (Not always visible).
- Side arm plates..... A series of plates, along each side of the arm (fig. 1, s. i. p.).
- Supplementary plates Small plates sometimes present on the sides of the upper arm plates, as in *Ophiopholis*, and *Ophionereis*.
- Tentacle pores..... Openings on the sides of the jaw and under arm plates, through which tentacles project in the living animal.
- Tentacle scales..... Small scales bordering the tentacle pores.
- Under arm plates.... A series of plates on the under side of the arms (fig. 1, u. a. p.).
- Upper arm plates.... A series of plates on the upper side of the arms (fig. 1, up. a. p.).

II. DESCRIPTION OF SPECIES

1. ARTIFICIAL KEY TO THE FAMILIES AND GENERA OF OPHIURANS IN MONTEREY BAY

- I. Disk and arms covered by a skin; arms capable of being bent toward the mouth; dorsal arm plates absent or very rudimentary.
 - a¹. Arms simple.....I. *Trichasteridæ*
 - b. Disk above and radial shields granulated; arms not very long and whip-like.....1. *Astroschema*
 - bb. Disk above and radial shields naked; arms very long and whip-like.....2. *Asteronyx*
 - a². Arms branched.....II. *Gorgonocephalidæ*
 - Disk and radial shields nearly bare or minutely granulated; genital slits begin at about middle of interbrachial space.....3. *Gorgonocephalus*
- II. Disk and arms not covered by thick skin; arms not capable of being vertically coiled; dorsal arm plates present.
 - a¹. Side arm plates meeting both above and below; no dental papillæ; long arm spines.....III. *Ophiacanthidæ*
 - Disk plates above hidden or nearly hidden by granules 4. *Ophiacantha*
 - a². Side arm plates not meeting both above and below.
 - b¹. Oral papillæ absent.....IV. *Ophiothricidæ*
 - Disk beset with spines; spine-like tentacle scale.....5. *Ophiothrix*
 - b². Oral papillæ present.
 - c¹. No vertical clump of dental papillæ; arms inserted on ventral side of disk; arm spines at strong angle with arm; supplementary plates, when present, more than two, and surrounding upper arm plates.....V. *Amphiuridæ*
 - d¹. Supplementary plates surrounding upper arm plates.....6. *Ophiopholis*
 - d². No supplementary plates
 - e¹. Disk beset with spines.....7. *Amphilimna*
 - e². Disk bare.
 - f¹. Oral papillæ two on a side; first oral tentacle scale appears like third oral papilla; interbrachial spaces bare in Monterey Bay species.....8. *Amphiura*
 - f². Three oral papillæ on a side; interbrachial spaces scaly.
 - g¹. Oral papillæ subequal.....9. *Amphiodia*
 - g². Distal oral papilla much longer than other two.....10. *Amphiopholis*
 - c². Arms inserted in a definite cleft in the disk; arm spines parallel with arm and closely appressed to it.....VI. *Ophiolepididæ*
 - d¹. Notch at edge of disk on upper side, where arms meet disk.....11. *Ophiura*
 - d². No notch at edge of disk.
 - e¹. Upper arm plates entire; radial shields large.....12. *Ophiocten*
 - e². Upper arm plates broken up into small plates; radial shields very small.....13. *Ophioplocus*

- c³. Arm spines at angle with arm; disk free of granules; supplementary plates one on either side of upper arm plate. . . VII. *Ophiochitonidae*
Tentacle scale single, large. 14. *Ophionereis*
- c⁴. Dental papillæ well developed; disk covered with granules. . .
. VIII. *Ophiocomidae*
Arm spines flat, blunt. 15. *Ophiopteris*
- c⁵. Arm spines at angle with arm. No supplementary plates; disk bare; differs from *Amphiuridae*, as keyed, in very small and inconspicuous radial shields, whereas *Amphiuridae* with bare disks have large and conspicuous radial shields. 16. *Ophionereis*, juv.

KEY TO THE LITTORAL SPECIES

- a¹. Disk granulated above.
b¹. Supplementary plates bordering upper arm plates; small spines on inter-brachial areas. *Ophiopholis aculeata* f. *kennerlyi*
b². No supplementary plates; interbrachial areas with small stumps or granules. *Ophiopteris papillosa*
- a². Disk not granulated.
b¹. Oral papillæ absent. *Ophiothrix spiculata*³
b². Oral papillæ present.
c¹. Upper arm plates divided into smaller plates; disk very flat. . .
. *Ophioplocus esmarki*
- c². Upper arm plates not divided.
d¹. Two small tentacle scales; radial shields conspicuous; three oral papillæ on each side of jaw.
e¹. Oral papillæ subequal; arm spines flat and blunt.
. *Amphiodia occidentalis*
e². Distal oral papilla much longer than other two; arm spines terete and sharp. *Amphipholis pugetana*
- d². One large tentacle scale; radial shields inconspicuous, about a large as disk scales; four oral papillæ on each side of jaw
. *Ophionereis* sp., juv.

Family I. TRICHAsterIDÆ

Genus *Asteroschema* Lütken

Asteroschema Lütken, 1856, Vid. med., p. 16.

Disk small, covered with granulated skin. Arms long and thin, covered with granulated skin that hides all plates. Genital slits small, almost vertical. Under arm plates pushed inside

³H. L. Clark (1915a), in his "Catalogue of Recent Ophiurans", lists *Ophiothrix dumosa* as occurring at Pacific Grove.

I have examined the specimens classified as *Ophiothrix dumosa*, some of them from Pacific Grove, California, in the Harvard Museum of Comparative Zoology at Cambridge, Massachusetts. This study has convinced me that *Ophiothrix dumosa* is synonymous with *Ophiothrix spiculata*, and that the specimens originally described by Lyman in 1860 were one of the many variations which occur in *Ophiothrix spiculata*. In this opinion Dr. H. L. Clark fully agrees with me. I shall speak of this matter more at length under "*Ophiothrix spiculata*".

the arms; side arm plates joining ventrally, and extending only slightly onto lateral faces. Two tentacle scales. No dental papillæ, no oral papillæ. A vertical series of teeth.

1. *Asteroschema sublæve* Lütken & Mortensen

Asteroschema sublæve Lütken & Mortensen, 1899, Mem. M. C. Z., 23, p. 187, pl. 22, f. 13, 14.

Disk diameters ranging from 13 to 16 mm. Arms naked below, or with very flat, scale-like particles, unlike granules, on sides of arms, and dorsal side of arms and disk; arm spines mostly two; in middle of arm the inner one is elongated, club-shaped.

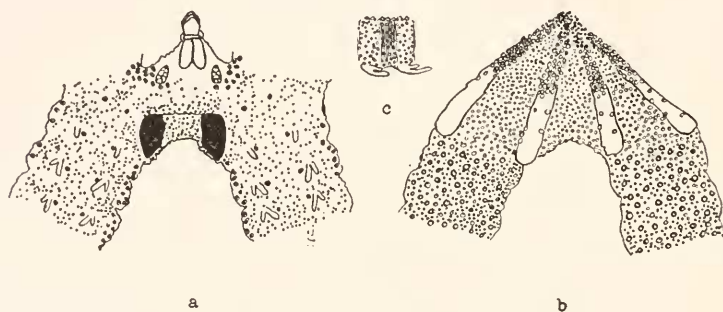


Fig. 2. *Asteroschema sublæve*, X2.5.—a, from below; b, from above; c, side view of two arm joints near disk.

My specimens show variations in (1) the presence or absence of tubes, made up of small scales, around the first tentacle; (2) the number of granules on the disk between the ribs, on the aboral side.

The tubes may be about 1 mm. long, as in the figure; they may be half of that, or they may not be present at all. The granulation may be almost as thick as on the ribs, or it may vary to nakedness on some segments of the disk.

Color in life. Aboral surface: Arms Chinese orange (scarlet vermilion+cadmium orange+burnt sienna). Disk orange in center, purplish between ribs. Oral surface: Papillæ of arms entire light or dark brown. Space between two bursal openings brown. Some specimens more deeply colored than others.

SPECIMENS OF *ASTEROSCHEMA* *SUBLÆVE* EXAMINED.—Six.

Station 4530, Point Pinos Light House, S. 78° E., 6.8 miles, 847-755 fathoms, soft gray mud, 4 specimens.

Station 4537, Point Pinos Light House, S. 74° E., 7.4 miles, 1062-861 fathoms, hard sand, mud, 2 specimens.

Bathymetrical range, 755 to 1062 fathoms.

Genus *Asteronyx* Müller & Troschel

Asteronyx Müller & Troschel, 1842, Syst. Ast., p. 85, 119.

Arms unbranched. The edges of the jaws are beset with sharp papillæ. No true teeth. The tentacle pores are bordered by hooks (tentacle scales).

2. *Asteronyx loveni* Müller & Troschel

Asteronyx loveni Müller & Troschel, 1842, Syst. Ast., p. 119, pl. 10, f. 3-5.

Disk naked, as well as arms. Arms long and whip-like. In each interbranchial space, in the proximal corner, lies a deepening, into which open the genital slits on either side. My specimens range in disk diameters from 5 to 45 mm.

Color in life. Aboral surface of arms saturn red (scarlet vermilion + cadmium orange); disk flame scarlet, brighter toward center; apical region between inner tips of ridges rich deep carmine. Oral surface of arms much paler; interbranchial area bluish toward center; oral tentacles deep rich vermilion; tentacle feet slightly darker than aboral surface.

Asteronyx loveni is usually associated with the pennatulid, *Balticina pacifica*, around the upper part of the stem of which it twines its arms. Dr. W. K. Fisher informs me that as near as he can recall practically all the specimens collected were found on tall, slender pennatulids.⁴

⁴At station 4530 the net came up with a sheaf of tall, slender, purplish pennatulids. Each pennatulid carried one to several bright reddish-orange *Asteronyx*—a truly gorgeous combination of color. Note by W. K. Fisher.

SPECIMENS OF ASTERONYX LOVENI EXAMINED.—

One hundred seventy-three.

Station	Locality	Depth, fathoms	Nature of bottom	Number of specimens
4442	Point Pinos Light House S. 67° W., 4.6 miles.....	26-31	fine gray sand....	1
4443	Point Pinos Light House, S. 69° W., 3.7 miles.....	32-37	fine gray sand....	1
4513	Point Pinos Light House, S. 31° E., 9.3 miles.....	456-389	green mud.....	4
4514	Point Pinos Light House, S. 39° E., 10.7 miles.....	406-394	green mud, rock..	2
4515	Point Pinos Light House, S. 18° E., 8.1 miles.....	495-198	green mud, coarse sand, shells....	1
4516	Point Pinos Light House, S. 49° E., 12.5 miles.....	756-718	green mud.....	4
4530	Point Pinos Light House, S. 78° E., 6.8 miles.....	847-755	soft gray mud....	108
4537	Point Pinos Light House, S. 74° E., 7.4 miles.....	1062-861 ^s	hard sand, mud..	3
4538	Point Pinos Light House, S. 85° E., 6.5 miles.....	871-795	hard gray sand..	48
4547	Point Pinos Light House, S. 82° E., 10.5 miles.....	1083	gray mud, rock...	1

Bathymetrical range, 26 to 1083 fathoms.

Family II. GORGONOCEPHALIDÆ

Genus *Gorgonocephalus* Leach*Gorgonocephalus* Leach, 1815, Zool. misc., 2, p. 51.

Arms branching. Genital slits at the external portion of the interbrachial spaces. Long styliform ribs. No real arm spines, but tentacle scales. Teeth, dental papillæ, and oral papillæ, all similar, spiniform.

3. *Gorgonocephalus eucnemis* Müller & Troschel

Astrophyton eucnemis Müller & Troschel, 1842, Syst. Ast., p. 123.

^sBottom temperature 38.5° Fahr.

Gorgonocephalus eucnemis Döderlein, 1900, Echinod. Olga-exp., p. 226, pl. 10, f. 1-4.

Disk and ribs very minutely granulated. Tentacle scales (arm spines) mostly three. Genital slits, beginning at distal portion of interbrachial spaces, rather wide.

Color in life. Aboral surface: Ribs of disk rufous; interspaces maroon; arms cinnamon rufous, barred with vinaceous cinnamon. Oral surface: Salmon buff; interbrachial areas rather deep ferruginous.

My specimens range in disk diameters from 9 mm. to 90 mm., making *Gorgonocephalus eucnemis* the largest Ophiuran in Monterey Bay.

One specimen from station 4543 was brought up attached to the gorgonian, *Psammogorgia arbuscula*. This specimen had a disk diameter of 9 mm. and was but slightly branched.

Gorgonocephalus eucnemis is commonly called "basket-star", by the fishermen of Monterey Bay.

SPECIMENS OF GORGONOCEPHALUS EUCNEMIS EXAMINED.—Five⁶

Station	Locality	Depth, fathoms	Nature of bottom	Number of specimens
4439	Point Pinos Light House, S. 38° W., 1.5 miles.....	42-40	gray sand, shells..	1
4441	Point Pinos Light House, N. 87° W., 1.7 miles.....	35-28	blue mud, sand, shells.....	1
4518	Point Pinos Light House, S. 42° E., 5.7 miles.....	76-66	hard sand.....	1
4543	Point Pinos Light House, S. 25° E., 5.4 miles.....	93-53	hard sand, rock...	1
4551	Point Pinos Light House, S. 9° E., 4.5 miles.....	56-46	coarse sand, shells, rock.....	1

Bathymetrical range, 28 to 93 fathoms.

⁶This species is common on appropriate bottom, at about 40 to 70 fathoms, W. K. F.

Family III. OPHIACANTHIDÆ

Genus **Ophiacantha** Müller & Troschel

Ophiacantha Müller & Troschel, 1842, Syst. Ast., p. 84, 106.

Disk thick, covered by a skin bearing spines or granules, partly or completely hiding the imbricated scales of the disk. No dental papillæ; teeth; seven to 16 long oral papillæ. Four to 11 arm spines on either side arm plate; side arm plates nearly or completely meeting above and below.

ARTIFICIAL KEY TO THE SPECIES OF OPHIACANTHA

- Distal oral papilla same thickness as others; disk closely granulated, so that no scales are seen..... *O. diplasia*
 Distal oral papilla much thicker than the others; underlying scaling seen more or less under granules..... *O. eurypoma*

4. ***Ophiacantha diplasia*** H. L. Clark

Ophiacantha diplasia H. L. Clark, 1911, Bull. 75, U. S. N. M., p. 209, f. 97.

Disk diameters ranging from 12 mm. to 25 mm. Disk closely covered with coarse, nearly spherical granules. On interbrachial spaces, the granules are elongated and pointed;

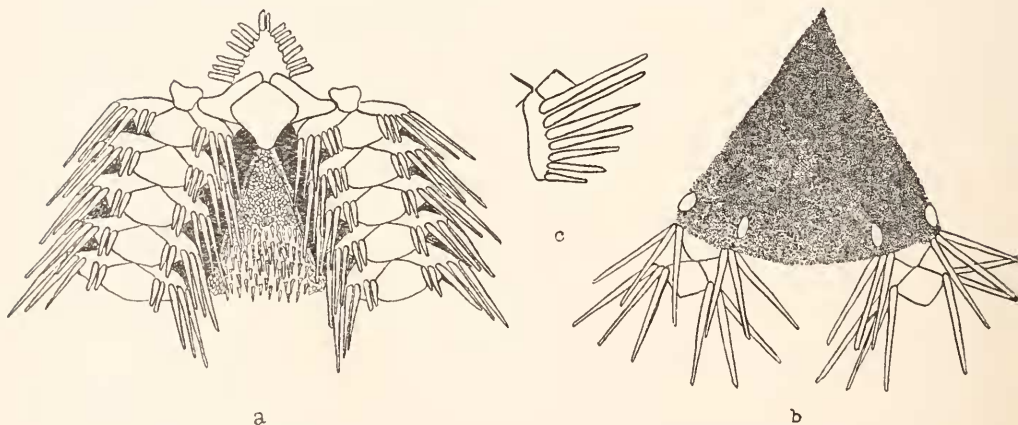


Fig. 3. *Ophiacantha diplasia*, X41.—a, from below; b, from above; c, side view of an arm joint near disk.

they cover the interbranchial spaces more or less. Oral papillæ five to seven on a side, long, narrow, subequal. Arm spines seven or eight on each side, long, hollow; uppermost spine longest. Tentacle scales two on each pore, long, flat, and blunt. Color (dried from alcohol). Disk, brown of some shade, ranging from very light to very dark. Arms and arm spines usually much lighter than disk and often nearly white; occasionally the disk is dark brown, mottled with a lighter shade.

SPECIMENS OF *OPHIACANTHA DIPLASIA* EXAMINED.—Thirty-two.

Station	Locality	Depth, fathoms	Nature of bottom	Number of specimens
4551	Point Pinos Light House, S. 9° E., 4.5 miles	56-46	coarse sand, shells, rock	2
4552	Point Pinos Light House, S. 73° E., 4 miles	73-66	green mud, rock . .	3
4554	Point Pinos Light House, S. 76° E., 3 miles	60-80	green mud, rock . .	20
4555	Point Pinos Light House S. 63°, E., 3.4 miles	66-69	green mud, rock . .	7

Bathymetrical range, 46 to 80 fathoms.

5. *Ophiacantha eurypoma* H. L. Clark

Ophiacantha eurypoma H. L. Clark, 1911, Bull. 75, U. S. N. M., p. 223, f. 103.

Disk diameters ranging from 6 mm. to 17 mm. Disk covered with stumps which are more or less rubbed off, leaving underlying scaling bare. Oral papillæ three on a side, and one at apex of jaw. The distal papilla is wide, squarish, while the others are narrow and long. Arm spines seven or eight, lowest smooth, next spines slightly thorny, upper spines smooth. Tentacle scale single, large, flat, blunt.

Color in life. Aboral side of disk: Radial shields and vicinity light yellowish vinaceous cinnamon; center of disk and ten radiating lines heliotrope purple; arms, vinaceous cinnamon, spines light vinaceous rufous. Oral side. Interbranchial area yellowish; arms flesh color.

November 21, 1924

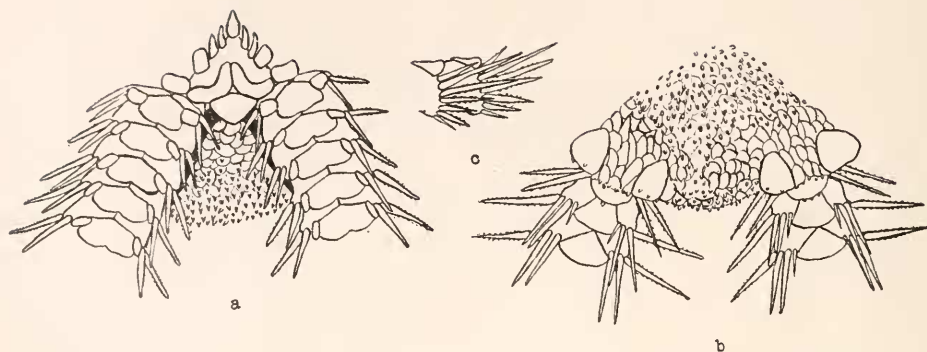


Fig. 4. *Ophiacantha eurypoma*, X3.6.—a, from below; b, from above; c, side view of two arm joints near disk.

SPECIMENS OF *OPHIACANTHA EURYPOMA* EXAMINED.—Forty-four from Station 4537, Point Pinos Light House, S. 74° E., 7.4 miles, 1062 to 861 fathoms, hard sand, mud.

Family IV. OPHIOTHRIXIDÆ

Genus *Ophiothrix* Müller & Troschel

Ophiothrix Müller & Troschel, 1840, Arch. Naturg., 6, p. 238.

Disk set with thorny grains or thorny spines. Radial shields large, triangular, swollen. Numerous crowded dental papillæ forming a vertical oval. Teeth. No oral papillæ. Five to 10 arm spines often three times as long as the arm joints. Usually a small, spine-like tentacle scale. The base of the jaw pierced with a hole. Interbrachial spaces swollen. Two genital slits, opening outside the oral shield. Outer arm joints with hooks.

6. *Ophiothrix spiculata* Leconte

Ophiothrix spiculata Leconte, 1851, Proc. Acad. Nat. Sci., Phila., 5, p. 318. McClendon, 1909, Univ. Calif. Publ. Zool., 6, pl. 6, f. 38, 39.

Ophiothrix dumosa Lyman, 1860, Proc. Boston Soc. Nat. Hist., 7, p. 252. 1865, Mem. Mus. Comp. Zool., Harvard, p. 169.

Disk diameters ranging between 2 mm. and 15 mm; disk, including radial shield, variably covered with thorny spines. Dental papillæ in a linear vertical oval, with a vertical row in the middle. One small tentacle scale. Seven long serrated arm spines; the second or third is the longest.

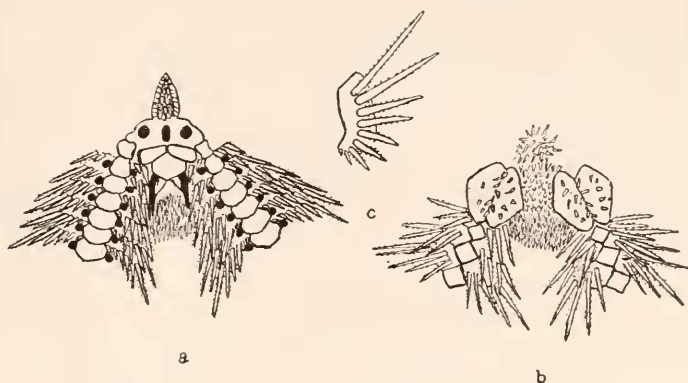


Fig. 5. *Ophiothrix spiculata*, X3.4.—a, from below; b, from above; c, side view of an arm joint near disk.

Color in life. Remarkable variation is seen here, and a great many different patterns are present. Aboral side of disk: Hessian brown, sepia, or dark greenish olive; or garnet brown spots on dark cress green background; or dark red with irregular gray and brown mottlings; or dark olive blue; or light olive. Arms: Olive citrine, crossed by reddish bands about every two plates, the bands being one plate wide; or dark greenish olive, spines tipped with pink; or light olive, with red cross-bands; or garnet brown spots on dark cress green background; or dark red mottled irregularly with gray and brown. Oral side: Interbrachial spaces and arms white near mouth. Interbrachial spaces zinc orange; or light olive; or gray; or dark olive. Ventral side of arms: Castor gray with reddish cross bands every two plates; or yellowish olive with cross bands of Dragon's blood red every three plates, covering one plate; or gray with light red bands; or light olive with cross bands of light red; or dark yellow crossed by light red bands.

As noted above, *Ophiothrix dumosa* is reported from Pacific Grove. Lyman (1865 p. 170) says of *Ophiothrix dumosa*:

"This species might be called a coarse edition of *Ophiothrix spiculata*, from which it is distinguished chiefly by the armature of the disk, which is coarser, and of a different character; the arm-spines, also, are rather stouter, and the under arm-plates more regular and angular." He also states (1865, p. 168) that *Ophiothrix spiculata* is "remarkable as a variable species".

Lyman erected *Ophiothrix dumosa* on the basis of a small series of specimens. He doubtless did not examine specimens in the field, and, although aware of the variability of *Ophiothrix spiculata*, was not cognizant of its full capacity for variation.

A careful study of the collection at the Museum of Comparative Zoölogy, has convinced me that *Ophiothrix dumosa* is simply one of the variants of *Ophiothrix spiculata*, and must be accepted as synonymous with the latter species. The differences between *Ophiothrix dumosa* and *Ophiothrix spiculata* are certainly much less than occur among any large series of specimens of *Ophiothrix spiculata*.

SPECIMENS OF OPHIOTHRIX SPICULATA EXAMINED.—

One hundred fifty-five.

Station	Locality	Depth, fathoms	Nature of bottom	Number of specimens
4439	Point Pinos Light House, S. 38° W., 1.5 miles.....	42-40	gray sand, shells..	1
4441	Point Pinos Light House, N. 87° W., 1.7 miles.....	35-28	blue mud, sand, shells.....	7
4496	Santa Cruz Light House, N. 80° W., 2.1 miles.....	10	fine gray sand, rock.....	1
4532	Point Pinos Light House, N. 76° E., 2.3 miles.....	30	gray sand, rock...	1
4558	Point Pinos Light House, S. 79° W., 2 miles.....	40-28	rock.....	4
	Off Del Monte.....	10-15	30
	Off Del Monte, June, 1906....	10-15	blue mud.....	96
	Monterey.....			2
	Pacific Grove, 1921.....	Low tide	rocky.....	13

Bathymetrical range, low tide to 42 fathoms.

Family V. AMPHIURIDÆ

Genus **Ophiopholis** Müller & Troschel

Ophiopholis Müller & Troschel, 1842, Syst. Ast., p. 96.

Disk more or less covered with grains or spinules. No dental papillæ; oral papillæ on the sides of the mouth frames. Arm spines short, flat, and stout; upper arm plates surrounded by a rim of supplementary pieces; the lowest spine of the distal arm joints is a hook. General structure coarse and stout. Two genital openings beginning outside the oral shields.

KEY TO THE SPECIES OF OPHIOPHOLIS

- Supplementary pieces few (six to 10 to each upper arm plate), large, angular, and crowded; arm spines short, rarely equal to a joint; disk with granules. *O. aculeata* f. *kennerlyi*
 Supplementary pieces very small, granule-like, commonly not in contact.
 Radial shields and disk more or less covered by slender spines; arm spines moderately long. *O. bakeri*
 Radial shields large and bare; disk spines few and long; arm spines very long. *O. longispina*

7. **Ophiopholis aculeata** forma **kennerlyi** (Lyman)

Ophiopholis kennerlyi Lyman, 1860, Proc. Bost. Soc. Nat. Hist., vol. 7, p. 200.

Ophiopholis aculeata var. *kennerlyi* H. L. Clark, 1911, Bull. U. S. N. M. 75, p. 132.

Disk with granules covering radial shields. Primary plates sometimes visible. Interbrachial spaces with spinules. Five arm spines. One small tentacle scale.

Disk diameters ranging from 3 mm. to 9 mm.

Color in life. There is considerable variation. Aboral side of disk: White center with ox-blood red markings; chocolate disk; or brownish olive with chestnut brown marblings; or Vandyke red; or mottlings intermixed of dark red and olive. Arms, dorsally, brownish olive with lateral bands and splotches of chocolate; or light brownish with irregular cross-bands of Pompeian red, from one to three plates wide; or mottled dark red and olive. Oral side of disk and arms, near mouth, white; interbrachial spaces chocolate, or olive, or dark dull yellow green. Arms, ventrally, pinkish, with cross-bands of reddish brown, which are irregular; or white crossed by vinaceous

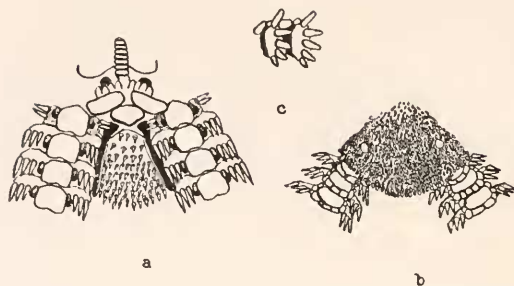


Fig. 6. *Ophiopholis aculeata* for. *kennerlyi*, X4.6.—a, from below; b, from above; c, side view of two arm joints near disk.

bands three plates wide; or white with magenta purple central line.

Although the form *kennerlyi* is found with perfect regularity as the representative of *Ophiopholis aculeata* in Monterey Bay, it is preferable to keep it as a variety, and not raise it to the rank of a geographical subspecies, as is well pointed out by Clark (1911, p. 115). On the other hand, because of the stability of this variety in the Bay, I have retained the varietal name.

SPECIMENS OF *OPHIOPHOLIS ACULEATA* forma *KENNERLYI*
EXAMINED.—Thirty-two.

Station	Locality	Depth, fathoms	Nature of bottom	Number of specimens
4441	Point Pinos Light House, N. 87° W., 1.7 miles.....	35-28	Blue mud, sand, shells.....	1
4496	Santa Cruz Light House, N. 80° W., 2.1 miles.....	10	fine gray sand, rock.....	1
4531	Point Pinos Light House, N. 64° E., 2.1 miles.....	26-28	fine gray Sand, pebbles, rock...	1
4532	Point Pinos Light House, N. 76° E., 2.3 miles.....	30	gray sand, rock...	5
4550	Point Pinos Light House, S. 6° E., 4.6 miles.....	50-57	green mud, rock..	1
	Monterey.....			13
	Off Del Monte, June 1906....	10-15	blue mud.....	7
	Pacific Grove, 1921.....	Littoral	rocky.....	3

Bathymetrical range, Intertidal to 57 fathoms.

8. *Ophiopholis bakeri* McClendon

Ophiopholis bakeri McClendon, 1909, Univ. Calif. Publ. Zool., 6, p. 41, pl. 5, f. 26, 27.

Disk diameters range between 2 mm. and 10 mm; radial shields as well as disk covered by thorny spinules more or less. Oral shields very wide. Four to six moderately long minutely thorny arm spines.

Color (dried from alcohol), pink or white.

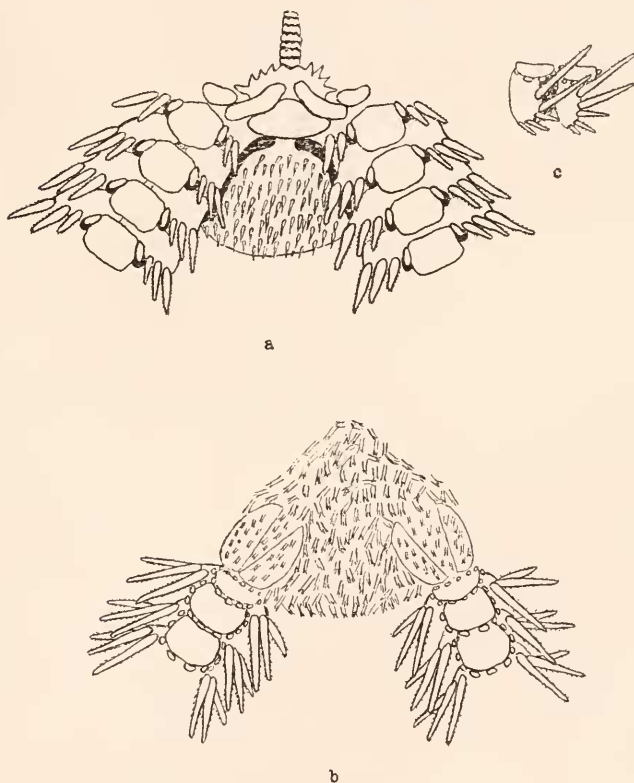


Fig. 7. *Ophiopholis bakeri*, X7.2.—a, from below; b, from above; c, side view of two arm joints near disk.

SPECIMENS OF OPHIOPHOLIS BAKERI EXAMINED.—Fifty-six.

Station	Locality	Depth, fathoms	Nature of bottom	Number of specimens
4441	Point Pinos Light House, N. 87° W., 1.7 miles.	35-28	blue mud, sand, shells.	4
4462	Point Pinos Light House, S. 5° W., 8.5 miles.	265-161	green mud.	3
4463	Point Pinos Light House, S. 17° W., 8 miles.	111-48	rocky.	2
4531	Point Pinos Light House, N. 64° E., 2.1 miles.	26-28	fine gray sand, pebbles, rock ...	3
4532	Point Pinos Light House, N. 76° E., 2.3 miles.	30	gray sand, rock ...	3
4535	Point Pinos Light House, N. 86° E., 3.7 miles.	71-54	hard gray sand. . .	10
4543	Point Pinos Light House, S. 25° E., 5.4 miles.	93-53	hard sand, rock ...	12
4551	Point Pinos Light House, S. 9° E., 4.5 miles.	56-46	coarse sand, shells, rock.	8
4552	Point Pinos Light House, S. 73° E., 4 miles.	73-66	green mud, rock. . .	2
4553	Point Pinos Light House, S. 67° E., 3.7 miles.	74-65	rock.	2
4554	Point Pinos Light House, S. 76° E., 3 miles.	60-80	green mud, rock. . .	4
4555	Point Pinos Light House, S. 63° E., 3.4 miles.	66-69	green mud, rock. . .	2
4558	Point Pinos Light House, S. 79° W., 2 miles.	40-28	rock.	1

Bathymetrical range, 26 to 265 fathoms.

9. *Ophiopholis longispina* H. L. Clark

Ophiopholis longispina H. L. Clark, 1911, Bull. 75, U. S. N. M., p. 119, f. 45.

Disk, 12 mm. in diameter, covered in large part by bare radial shields. Between these are long, slender spines. Six to eight slender, long, bluntly pointed arm spines.

Color in life. Aboral surface of disk olive-gray, plumbeous, pink adjacent to base of arms; spinelets on disk light brownish;

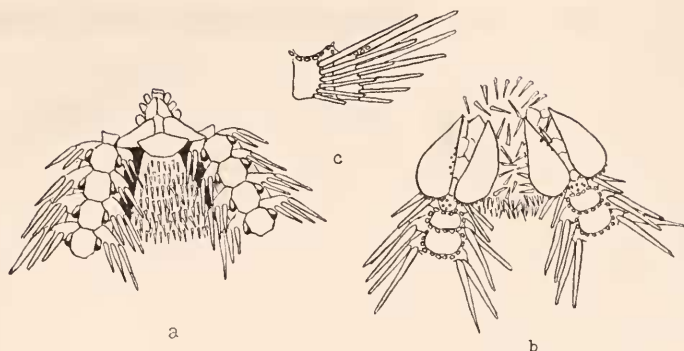


Fig. 8. *Ophiopholis longispina*, X3.6.—a, from below; b, from above; c, side view of two arm joints near disk.

arms rose-pink; spines nearly white. Oral surface: Inter-brachial spaces brownish at edge, grayish medially; arms cream white, pinkish at tip.

SPECIMENS OF *OPHIOPHOLIS LONGISPINA* EXAMINED.—

One from station 4514, Point Pinos Light House, S. 39° E., 10.7 miles, 406 to 394 fathoms, green mud, rocks.

Genus ***Amphilimna*** Verrill

Amphilimna Verrill, 1899, Bull. Univ. Iowa, new ser., 1, No. 6, p. 30.

Oral papillæ four or five in a series; dental papillæ two to four. Arm-spines six to 10, of moderate length. Tentacle-scales usually two. Disk swollen dorsally, with a notch over the base of each arm, and covered with spinules. Radial shields parallel, largely in contact.

10. ***Amphilimna pentacantha*** H. L. Clark

Amphilimna pentacantha H. L. Clark, 1911, Bull. 75, U. S. N. M., p. 172, f. 77.

Disk diameters ranging from 5 mm. to 10 mm. Many disk scales carry minute sharp spines. Radial shields long, narrow. Five arm spines at base of arm, three toward middle of arm. Tentacle scales two.

Color (dried from alcohol). Disk gray, arms yellowish white.

SPECIMENS OF AMPHILIMNA PENTACANTHA EXAMINED.—
Twenty-three.

Station	Locality	Depth, fathoms	Nature of bottom	Number of specimens
4445	Point Pinos Light House, S. 13° E., 6 miles.....	66-60	green mud.....	1
4448	Point Pinos Light House, S. 41° W., 4.8 miles.....	45-34	green mud.....	1
4452	Point Pinos Light House, S. 21° W., 3.4 miles.....	49-50	green mud, fine sand.....	2
4457	Point Pinos Light House, S. 21° W., 6.1 miles.....	46-40	dark green mud..	2
4464	Point Pinos Light House, S. 20° W., 7.8 miles.....	51-36	soft dark gray mud.....	1
4475	Point Pinos Light House, S. 15° W., 9.7 miles.....	85-58	soft green mud...	2
4480	Santa Cruz Light House, N. 31° W., 6.1 miles.....	76-53	dark green mud, sand.....	2
4482	Santa Cruz Light House, N. 39° W., 8.7 miles.....	43-44	soft green mud...	3
4523	Point Pinos Light House, S. 17° W., 9.5 miles.....	108-75	soft dark mud...	1
4548	Point Pinos Light House, S. 26° W., 3 miles.....	46-54	coarse sand, shells, rock.....	1
4549	Point Pinos Light House, S. 9° W., 2.6 miles.....	56-57	coarse sand, shells, rock.....	4
4556	Point Pinos Light House, S. 7° E., 3.7 miles.....	56-59	rock.....	3

Bathymetrical range, 34 to 108 fathoms.

Genus **Amphiura** Forbes

Amphiura Forbes, 1843, Trans. Lin. Soc., 19, p. 149. Type designated by Verrill, 1899, Bull. Univ. Iowa, new ser., 1, No. 6, p. 24.

One apical or subapical oral papilla; one (rarely two) small, distal papilla (oral tentacle scale); middle of jaw-edge without papillæ; mouth slits gaping. Four to seven or more (rarely three) arm spines. Radial shields divergent.

KEY TO THE SPECIES OF AMPHIURA

- Arm spines at base of arm, five; a portion of disk, on aboral side, often naked
.....*A. arcystata*
Arm spines at base of arm three or four; disk always scaly on aboral side
.....*A. seminuda*

11. *Amphiura arcystata* H. L. Clark

Amphiura arcystata (err. typ.) H. L. Clark, 1911, Bull. 75, U. S. N. M., p. 145, f. 58.

Disk diameters ranging from 4 mm. to 7 mm.; disk usually naked at center and in the interradii, with scaling around the radial shields; or sometimes scaled completely on aboral side. Interbranchial spaces usually naked. Two oral papillæ, but first tentacle scale is easily mistaken for a third papilla. Five arm spines near disk. Color (dried from alcohol). Disk and arms light orange; skin brown; scales grayish white.

SPECIMENS OF AMPHIURA ARCYSTATATA EXAMINED.—Four.

Station 4510, Point Pinos Light House, S. 15° W., 9.3 miles, 156-91 fathoms, gray mud, 2 specimens.

Station 4549, Point Pinos Light House, S. 9° W., 2.6 miles, 56-57 fathoms, coarse sand, shells, rock, 2 specimens.

Bathymetrical range, 56 to 156 fathoms.

12. *Amphiura seminuda* Lütken & Mortensen

Amphiura seminuda Lütken & Mortensen, 1899, Mem. M. C. Z., 23, p. 148, pl. 11, f. 1-3.

Disk diameters ranging from 5 mm. to 9 mm.; disk scaled. One infradental papilla, and one side papilla, on each side. Interbranchial spaces naked, with a band of scales along the margin. In the Monterey Bay specimens, there are often four spines at the base of the arm. On the same individual, some arms have three, and some have four spines at the base of the arm, near the disk. All have three spines distally. The radial shields are divergent the whole length.

Color in life. Disk, lead color; arms yellowish white.

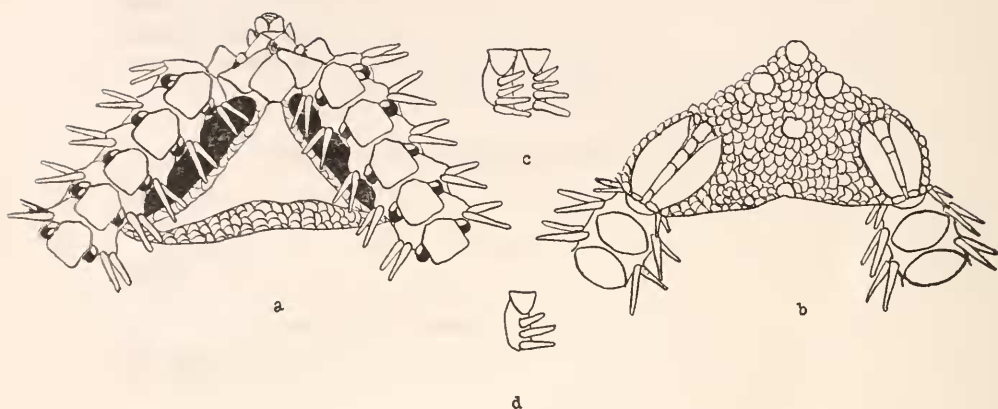


Fig. 9. *Amphiura seminuda*, X9.4.—a, from below; b, from above; c, side view of two arm joints near disk; d, side view of an arm joint about middle of arm.

SPECIMENS OF *AMPHIUIRA SEMINUDA* EXAMINED.—Fifteen.

Station	Locality	Depth, fathoms	Nature of bottom	Number of specimens
4462	Point Pinos Light House, S. 5° W., 8.5 miles.....	265-161	green mud.....	2
4463	Point Pinos Light House, S. 17° W., 8 miles.....	111-48	rocky.....	2
4509	Point Pinos Light House, S. 13° W., 8.6 miles.....	286-152	soft gray mud....	2
4515	Point Pinos Light House, S. 18° E., 8.1 miles.....	495-198	green mud, coarse sand, shells....	1
4517	Point Pinos Light House, S. 52° E., 9.1 miles.....	766-750	green mud, sand..	1
4528	Point Pinos Light House, S. 58° E., 12.7 miles.....	766-800	soft gray mud....	1
4537	Point Pinos Light House, S. 74° E., 7.4 miles.....	1062-861	hard sand, mud..	4
4546	Point Pinos Light House, S. 46° E., 8.4 miles.....	849	fine black sand, rock.....	2

Bathymetrical range, 48 to 1062 fathoms.

Genus **Amphiodia** Verrill

Amphiodia Verrill, 1899, Bull. Univ. Iowa, new ser., 1, No. 6, p. 25.

Three (rarely four) small subequal oral papillæ, none of them operculiform; they form a regular series, attached mostly to the side jaw-plate. Three (rarely four) arm spines. Radial shields often more or less joined.

KEY TO THE SPECIES OF AMPHIODIA

- Arm spines flat, blunt.....*A. occidentalis*
Arm spines sharp, terete.
Marginal row of distinct scales to disk.....*A. periercta*
No marginal scales. Some of the disk scales near the arm have fine prickles
on their edges.....*A. urtica*

13. **Amphiodia occidentalis** (Lyman)

Amphiura occidentalis Lyman, 1860, Proc. Boston Soc. Nat. Hist., 7, p. 194; 1865, Illus. Cat. M. C. Z., No. 1, p. 130, f. 12, 13.

Amphiodia occidentalis Verrill, 1899, Trans. Conn., Acad., 10, p. 313.

Disk diameters ranging from 3 mm. to 9 mm.; disk covered with scales which do not bear prickles; radial shields may be completely separated, or joined for nearly their whole length. Arm spines flat, blunt.

Color in life. There is considerable variation. Aboral side of disk: Light gray; or smoke gray; or grayish white with reddish markings on it and radial shields. Dorsal side of arms: Whitish, with irregular iron gray markings; or yellowish with light gray markings; or whitish with irregular peach red markings very widely distributed, and spines flesh pink. Oral side: Interbrachial spaces, light gray, or grayish with reddish mark-

ings; arms, whitish with light gray markings; or light cream yellow with irregular blackish gray markings; or peach red, and spines flesh pink.

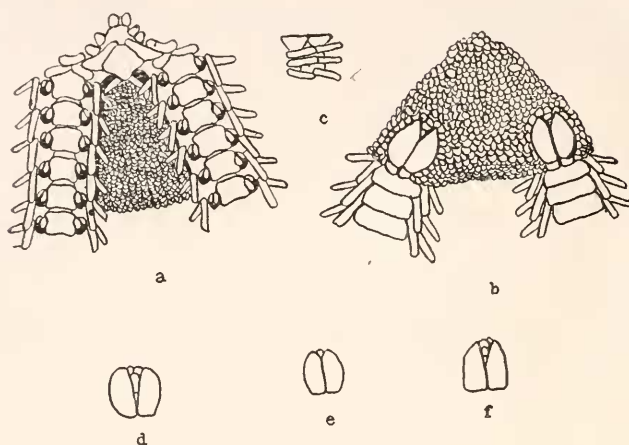


Fig. 10. *Amphiodia occidentalis*, X10.—a, from below; b, from above; c, side view of two arm joints near disk; d, e, f, variations in radial shields.

SPECIMENS OF *AMPHIODIA OCCIDENTALIS* EXAMINED.—

Seventy-one, from Pacific Grove, intertidal; and from off Del Monte, 10 to 15 fathoms, June 1906, 4 specimens.

Bathymetrical range, low tide to 15 fathoms.

14. *Amphiodia periercta* H. L. Clark

Amphiodia periercta H. L. Clark, 1911, Bull. 75, U. S. N. M., p. 156, f. 68.

Disk diameters ranging from 3 mm. to 8 mm.; disk margin formed by a row of quite distinct scales, which may stand more or less erect and be bluntly pointed. Upper arm plates very wide; arm spines sharp, terete.

Color (dried from alcohol), pale fawn color, or yellowish brown.

SPECIMENS OF AMPHIODIA PERIERCTA EXAMINED.—Thirteen.

Station	Locality	Depth, fathoms	Nature of bottom	Number of specimens
4454	Point Pinos Light House, S. 13° E., 8.3 miles.....	71-65	green mud, sand, gravel.....	8
4543	Point Pinos Light House, S. 25° E., 5.4 miles.....	95-53	hard sand, rock..	1
4549	Point Pinos Light House, S. 9° W., 2.6 miles.....	56-57	coarse sand, shells, rock.....	1
4550	Point Pinos Light House, S. 6° E., 4.6 miles.....	50-57	green mud, rock	2
4551	Point Pinos Light House, S. 9° E., 4.5 miles.....	56-46	coarse sand, shells, rock.....	1

Bathymetrical range, 46 to 71 fathoms.

Since some doubts have been expressed as to the possible distinctness of *Amphiodia peloria* Busch from *Amphiodia periercta* H. L. Clark, I made a careful study of both species at the Museum of Comparative Zoölogy, having at my disposal the type of *Amphiodia peloria* Busch and the cotype of *Amphiodia periercta* H. L. Clark. In my opinion the differences are marked and one could not mistake one species for the other. In *A. peloria* the arms are over 15 times the diameter of the disk, the arm spines are flat, the oral shields are circular or nearly so, the adoral plates scarcely meet, the two tentacle scales are widely separated from each other on the proximal half of the arm. In *A. periercta* the arms are about 10 times the diameter of the disk, the arm spines are terete, the oral shields are angular, the adoral plates meet fully, the two tentacle scales lie close to each other on the proximal as well as on the distal half of the arm. The two species are thus quite distinct.

15. *Amphiodia urtica* (Lyman)

Amphiura urtica Lyman, 1860, Proc. Boston Soc. Nat. Hist., 7, p. 195.

Amphiodia urtica Verrill, 1899, Trans. Conn. Acad., 10, p. 313; H. L. Clark, 1911, Bull. 75, U. S. N. M., p. 154, f. 64.

Disk diameters ranging from 3 mm. to 6 mm.; some of the disk-scales, mostly near arms, bearing fine prickles on their edges; these can best be seen with the low power of a compound microscope. Upper arm plates with outer side less curved than inner side. The radial shields may be completely separated by a series of scales, or may be joined for most of their length. Arm spines terete, sharp.

Color (dried from alcohol). Disk dark or light gray; arms white or light straw color.

SPECIMENS OF AMPHIODIA URTICA EXAMINED.—Seventy-seven.

Station	Locality	Depth, fathoms	Nature of bottom	Number of specimens
4446	Point Pinos Light House, S. 2° W., 5 miles.....	59-52	green mud.....	1
4452	Point Pinos Light House, S. 21° W., 3.4 miles.....	49-50	green mud, fine sand.....	15
4453	Point Pinos Light House, S. 17° W., 2.3 miles.....	49-51	dark green mud..	2
4457	Point Pinos Light House, S. 21° W., 6.1 miles.....	46-40	dark green mud..	3
4464	Point Pinos Light House, S. 20° W., 7.8 miles.....	51-36	soft dark gray mud.....	21
4523	Point Pinos Light House, S. 17° W., 9.5 miles.....	108-75	soft dark mud...	2
4549	Point Pinos Light House, S. 9° W., 2.6 miles.....	56-57	coarse sand, shells, rock.....	28
4550	Point Pinos Light House, S. 6° E., 4.6 miles.....	50-57	green mud, rock..	5

Bathymetrical range, 36 to 108 fathoms.

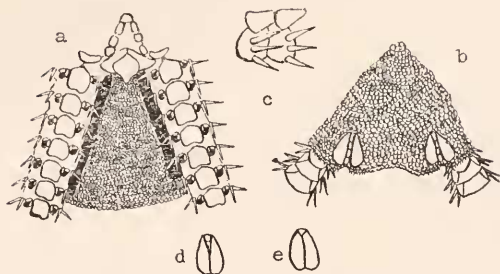


Fig. 11. *Amphiodia urtica*, X10.—a, from below; b, from above; c, side view of two arm joints near disk; d, e, variations in radial shields. In b, the specimen has been distorted through drying. The radial shields naturally lie on either side of the arm.

Genus *Amphipholis* Ljungman

Amphipholis Ljungman, 1866, Öfv. Kongl. Vet.-akad. Förh., 23, p. 165.

Two small lateral oral papillæ and one broad operculiform, distal one, forming a continuous series along the entire jaw, and capable of nearly or quite closing the mouth-slits. Radial shields in close contact.

16. *Amphipholis pugetana* (Lyman)

Amphiura pugetana Lyman, 1860, Proc. Boston Soc. Nat. Hist., 7, p. 193.

Amphipholis pugetana Ljungman, 1867, Öfv. Kongl. Vet.-akad. Förh., 23, p. 312; McClendon, 1909, Univ. Calif. Publ. Zool., 6, p. 43, pl. 2, f. 12, 13.

Disk diameters ranging from 1 mm. to 4 mm. Radial shields meeting along their whole length. Distal oral papilla long, operculiform. Three terete, sharp, arm spines.

Color in life. There is some variation. Aboral side of disk, reddish brown, or pink, or dark gray; arms, dorsally, white, with mottlings of light gray; or white with blackish irregular marblings. Oral side: Interbrachial spaces, light pink, or light gray; arms, white with very light gray mottlings.

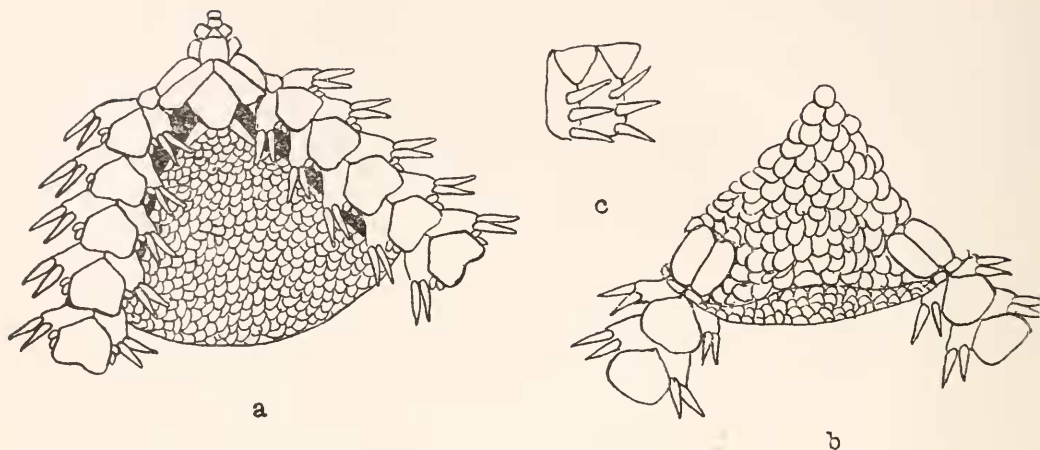


Fig. 12. *Amphipholis pugetana*, X21.5.—a, from below; b, from above; c side view of two arm joints near disk.

SPECIMENS OF AMPHIPHOLIS PUGETANA EXAMINED.—Forty-seven.

Station 4496, Santa Cruz Light House, N. 80° W., 2.1 miles, 10 fathoms, fine gray sand, rock, 1 specimen.

Station 4520, Point Pinos Light House, S. 28° W., 11.2 miles, 32-44 fathoms, green mud, 1 specimen.

Off Del Monte, June, 1906, 10-19 fathoms, blue mud, 2 specimens.

Monterey and Pacific Grove, intertidal, 43 specimens.

Bathymetrical range, low tide to 44 fathoms.

Family VI. OPHIOLEPIDIDÆ

Genus *Ophiura* Lamarck

Ophiura Lamarck, 1816, Anim. sans Vert., 2, p. 540.

Disk covered with scales which are often swollen. In the disk, over the base of the arm, is a notch usually edged with papillæ. Two genital openings starting from the sides of the mouth shield. Arm spines short and smooth, rarely exceeding the length of a joint. Tentacle scales numerous, the innermost pair of tentacle pores shaped like slits surrounded by numerous tentacle scales and opening diagonally into the mouth slit. Teeth. No dental papillæ. Oral papillæ long within, but small and short near outer end of the mouth slit and partly hidden by the scales of the oral tentacles.

KEY TO THE SPECIES OF OPHIURA

- Arm comb made up of very slender papillæ, their length at least five times their thickness. *O. leptoctenia*
 Arm comb made up of short, broad, truncate papillæ, which are closely crowded side by side, so that there is no resemblance to a comb. *O. lütkenii*

17. *Ophiura leptoctenia* H. L. Clark

Ophiura leptoctenia H. L. Clark, 1911, Bull. 75, U. S. N. M., p. 51, f. 12.

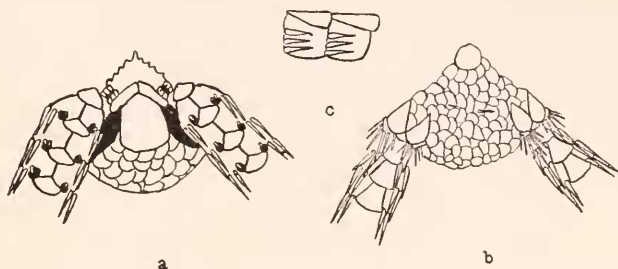


Fig. 13. *Ophiura leptoctenia*, X9.2.—a, from below; b, from above; c, side view of two arm joints near disk.

Disk diameter of specimen, 4 mm.; disk covered with imbricated scales. Under arm plates small, widely separated; arm comb of papillæ more or less needle-like; three sharp arm spines nearly as long as a joint. Tentacle scale on arm pores spine-like, not rounded. Color (dried from alcohol), white.

SPECIMEN OF OPHIURA LEPTOCTENIA EXAMINED.—One from Station 4536, Point Pinos Light House, S. 65° E., 9.6 miles, 1006-1041 fathoms, hard sand, mud.

18. *Ophiura lütkenii* (Lyman)

Ophioglypha lütkenii Lyman, 1860, Proc. Boston Soc. Nat. Hist., 7, p. 197.

Ophiura lütkenii Meissner, 1901, Brown's Thierreichs, 2, abt. 3, p. 925; McClendon, 1909, Univ. Calif. Publ. Zool., 6, pl. 6, f. 32, 33.

(See figure 1, page 265)

Disk diameters ranging from 4 mm. to 22 mm. Length of arm about 5.5 times diameter of disk. Radial shields small, ovoid, pointed within. A notch above the base of the arm. Three tapering arm spines, the dorsal one about as long as the arm joint. Arm comb of short, broad, truncate papillæ, which are closely crowded side by side, so that there is no resemblance to a comb.

Color in life. "Salmon red with cinnamon". Dried from alcohol: Gray on disk and arms on aboral side, with white spots often present on disk; aboral side grayish white. (The color and markings in life are extremely variable.—W.K.F.)

SPECIMENS OF *OPHIURA LÜTKENII* EXAMINED.—
Seven hundred ninety-seven.

Station	Locality	Depth, fathoms	Nature of bottom	Number of specimens
4439	Point Pinos Light House, S. 38° W., 1.5 miles.....	42-40	gray sand, shells..	2
4441	Point Pinos Light House, N. 87° W., 1.7 miles.....	35-28	blue mud, sand, shells.....	1
4444	Point Pinos Light House, S. 67° W., 2.9 miles.....	40	fine gray sand....	1
4446	Point Pinos Light House, S. 2° W., 5 miles.....	59-52	green mud.....	144
4447	Point Pinos Light House, S. 21° W., 4.5 miles.....	52-42	green mud.....	7
4452	Point Pinos Light House, S. 21° W., 3.4 miles.....	49-50	green mud, fine sand.....	13
4453	Point Pinos Light House, S. 17° W., 2.3 miles.....	49-51	dark green mud..	19
4454	Point Pinos Light House, S. 13° E., 8.3 miles.....	71-65	green mud, sand, gravel.....	1
4455	Point Pinos Light House, S. 6° E., 7.6 miles.....	62-56	green mud.....	2
4457	Point Pinos Light House, S. 21° W., 6.1 miles.....	46-40	dark green mud..	55
4460	Point Pinos Light House, S. 12° E., 10.8 miles.....	55-671	green mud, gravel	7
4461	Point Pinos Light House, S. 3° E., 9.3 miles.....	285-357	green mud.....	2

SPECIMENS OF OPHIURA LÜTKENII EXAMINED.—Continued.

Station	Locality	Depth, fathoms	Nature of bottom	Number of specimens
4464	Point Pinos Light House, S. 20° W., 7.8 miles.....	51-36	soft dark gray mud	27
4465	Point Pinos Light House, S. 29° W., 7.6 miles.....	31-21	hard gray sand...	2
4467	Santa Cruz Light House, N. 28° W., 8.8 miles.....	54-51	soft dark green mud.....	10
4468	Santa Cruz Light House, N. 32° W., 10.3 miles.....	51-309	fine sand.....	8
4473	Point Pinos Light House, S. 15° E., 2.8 miles.....	54-65	gray sand, mud...	16
4474	Point Pinos Light House, S. 34° W., 1.2 miles.....	43-34	hard sand, mud...	161
4475	Point Pinos Light House, S. 15° W., 9.7 miles.....	85-58	soft green mud...	1
4477	Point Pinos Light House, S. 31° W., 9.2 miles.....	19-11	soft green mud...	5
4478	Santa Cruz Light House, N. 13° W., 3.8 miles.....	30	hard sand.....	1
4479	Santa Cruz Light House, N. 25° W., 5.1 miles.....	33-45	hard sand.....	4
4480	Santa Cruz Light House, N. 31° W., 6.1 miles.....	76-53	dark green mud, sand.....	7
4482	Santa Cruz Light House, N. 39° W., 8.7 miles.....	43-44	soft green mud...	40
4489	Santa Cruz Light House, N. 42° W., 3.7 miles.....	20-18	dark gray sand...	4
4492	Santa Cruz Light House, N. 54° W., 7 miles.....	26-27	soft green mud, rock.....	151
4521	Point Pinos Light House, S. 25° W., 10.8 miles.....	119-140	dark green mud...	2
4535	Point Pinos Light House, N. 86° E., 3.7 miles.....	71-54	hard gray sand...	1
4548	Point Pinos Light House, N. 26° W., 3 miles.....	46-54	coarse sand, shells, rock.....	3
4550	Point Pinos Light House, S. 6° E., 4.6 miles.....	50-57	green mud, rock...	26
4551	Point Pinos Light House, S. 9° E., 4.5 miles.....	56-46	coarse sand, shells, rock.....	2

SPECIMENS OF OPHIURA LÜTKENII EXAMINED.—Continued.

Station	Locality	Depth, fathoms	Nature of bottom	Number of specimens
	Near Bell Buoy, 11th haul.....	241	rocky.....	6
	Off Del Monte.....	28	shell.....	1
	Monterey Bay.....			65

Bathymetrical range, 11 to 357 fathoms.

Ophiura lütkenii is the most abundant deep-sea species in Monterey Bay.

Genus **Ophiocten** Lütken

Ophiocten Lütken, 1855, Vid. med. f. 1854, p. 102.

Disk thick and circular. No notch in the disk at the base of the arms. Side arm plates come together below, but not above. The broad oral tentacle is enclosed between the first ventral arm plate and the outer edge of the side arm plate. Teeth; oral papillæ; no dental papillæ. Two genital openings beginning at the side of the oral shield.

KEY TO THE SPECIES OF OPHIOCTEN

- No arm comb. Arm spines six to eight.....*O. culveri* new species
 Arm comb. Arm spines three.....*O. hastatum*

19. **Ophiocten culveri** May, new species

Disk 16.5 mm. in diameter. Arms broken, about 62 mm. long. Disk very flat, covered by a coat of scales among which the primary plates and the radial shields are prominent. Scales irregular in size, some much larger than others. Radial shields with inner sides flat, outer sides rounded, somewhat oval or slightly triangular, with rounded corners; the two radial shields are separated completely by one, two, or three rows of scales. Upper arm plates tetragonal, lateral margins somewhat divergent, wider than long at base of arm, but soon becoming squarish or very slightly longer than wide.

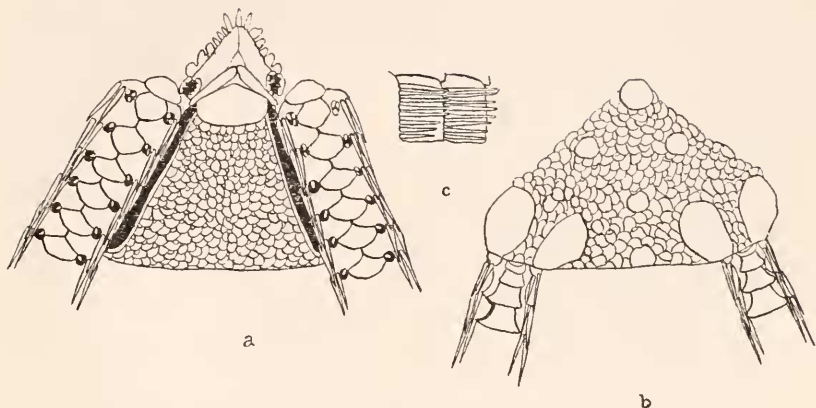


Fig. 14. *Ophiocten culveri*, X4.—a, from below; b, from above; c, side view of two arm joints near disk.

Interbrachial spaces below covered by about 60 irregularly sized scales, as on disk. Oral shields fairly large, pentagonal, wider than long. Adoral plates narrow, going to sides of oral shield; they meet proximally, leaving a triangular space between the oral shield and their point of meeting. Oral plates rather large. Oral papillæ about six on a side, and an apical papilla; apical papilla, and one papilla on either side long, pointed; other papillæ irregular, sometimes dentate. Genital slits long; genital scales not present, but slits bordered by one or two very long, narrow plates. No marginal papillæ to genital slits. No trace of an arm comb. Under arm plates wider than long; first two plates in contact, but other plates separated. First two plates tetragonal, succeeding plates triangular, with outer corners rounded, becoming pentagonal toward tip of arms. Side arm plates rather large, meeting below beyond second plate, but not above; each plate carries six to eight narrow, sharp arm spines, of which the uppermost is usually the longest, and about equal to an arm joint; the other spines are successively shorter. Oral tentacle pore surrounded by six to eight scales. First three arm pores with two or three scales; succeeding tentacle pores with single pointed scale.

Color (dried from alcohol), pale brownish gray.

Color in life. Aboral side of disk, vermilion irregularly washed with plumbeous; arms light orange vermilion. Oral side: Interbranchial spaces same as disk; under arm plates yellowish white.

Type: No. E1199, U. S. Nat. Mus., collected by the U. S. Bureau of Fisheries' steamer Albatross, in 1904, in **Monterey Bay**. (Exact locality not recorded). United States National Museum, Washington, D. C.

I take pleasure in naming this species in honor of George B. Culver, Dean of Men, Stanford University, my first teacher in Zoölogy.

This species differs from *Ophiocten hastatum* in having six to eight arm spines instead of three, in the absence of an arm comb, and in more numerous oral papillæ usually.

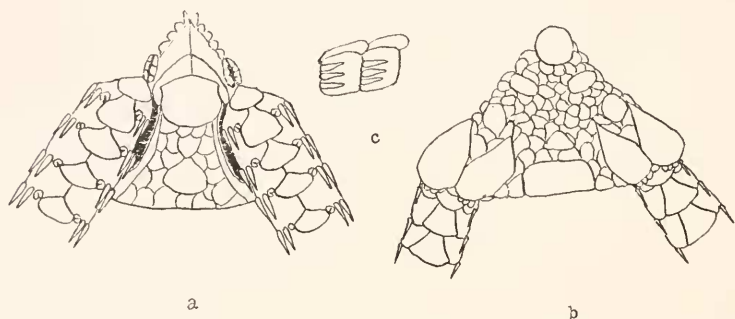


Fig. 15. *Ophiocten hastatum*, X8.6.—a, from below; b, from above; c, side view of two arm joints near disk.

20. *Ophiocten hastatum* Lyman

Ophiocten hastatum Lyman, 1878, Bull. Mus. Comp. Zool., 5, figs. 133, 134; Koehler, 1922, Bull. U. S. N. M. 100, vol. 5, p. 388.

Ophiocten pacificum Lütken & Mortensen, 1899, Mem. M. C. Z. 23, p. 131, pl. 3, f. 5-7.

Diameters of disk ranging from 6 mm. to 8 mm. Five to six pairs of oral papillæ in each jaw, the inner one spinous.

Arm comb continuous with genital papillæ; three arm spines, sharp, slender, tapering.

Color (dried from alcohol), gray or light brown.

SPECIMENS OF *OPHIOCTEN HASTATUM* EXAMINED.—Four, from Station 4537, Point Pinos Light House, S. 74° E., 7.4 miles, 1062-861 fathoms, hard sand, mud.

Through Mr. Austin H. Clark, of the United States National Museum, I learned that Dr. René Koehler, in a forthcoming work on Philippine Ophiurans (op. cit.), had synonymised *Ophiocten pacificum* Lütken & Mortensen, with *Ophiocten hastatum* Lyman. I then made a careful study of the cotypes of both species in the Museum of Comparative Zoölogy, and came to the same conclusion as Koehler, since the specimens all showed essentially the same characteristics.

Genus *Ophioplocus* Lyman

Ophioplocus Lyman, 1861, Proc. Boston Soc. Nat. Hist., 8, p. 75.

Disk closely and finely scaled above and below. Genital scales hidden. Teeth. No dental papillæ. Numerous even, close-set, oral papillæ. Adoral plates wide and nearly or quite meeting within. Three short arm spines. Upper arm plates, near tip of arm, divided on midline into halves, which at base of arm are removed to outer lower corner of joint on each side and separated by a number of supplementary pieces. Two short genital openings in each interbrachial space extending only half way to the margin of the disk, and beginning outside the oral shields.

21. *Ophioplocus esmarki* Lyman

Ophioplocus esmarki Lyman, 1874, Bull. M. C. Z., 3, 227.

Disk diameters ranging from 6 mm. to 17 mm. Upper arm plates broken up and separated by small supplementary plates. Radial shields very small and inconspicuous. My specimens have usually only two arm spines. An arm may have three

spines mostly, or only a few groups of three spines, or all groups of two spines, which is the case usually. Some specimens have two spines on all the arms.

Color in life. There is some diversity; young specimens are lighter in color than older specimens. Aboral side of disk and arms, warm sepia, cinnamon brown, or buckthorn brown; or disk neutral gray, while arms are vinaceous buff. Oral side of disk, snuff brown, dresden brown, orange cinnamon, pinkish cinnamon, warm buff, neutral gray. Ventral side of arms, orange cinnamon, tawny, warm buff, pinkish cinnamon, vinaceous buff, cinnamon.

SPECIMENS OF *OPHIOPLOCUS ESMARKI* EXAMINED.—Twenty-nine, from Pacific Grove, and the region between Point Pinos and Carmel Bay; intertidal.

Family VII. OPHIOCHITONIDÆ

Genus *Ophionereis* Lütken

Ophionereis Lütken, 1859, Add. ad. hist., Oph., Pt. 2, p. 110.

Disk covered with fine overlapping scales, radial shields nearly hidden by scales. Teeth large, oblong; mouth angle small and short and bearing 9 to 10 small, close-set papillæ. A few (3 to 5) short, smooth, arm spines; one large tentacle scale; each upper arm plate has a supplementary piece on either side. Two genital openings beginning outside the oral shield.

22. *Ophionereis eurybrachyplax* H. L. Clark

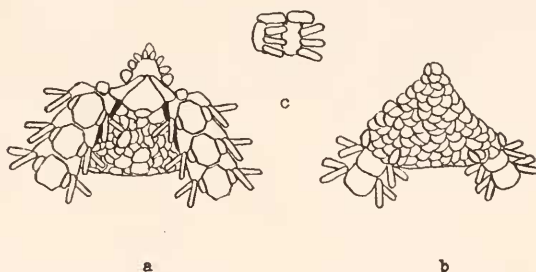
Ophionereis eurybrachyplax H. L. Clark, 1911, Bull. 75, U. S. N. M., p. 173, f. 78.

Disk diameters ranging from 11 mm. to 23 mm. Supplementary pieces small. Upper arm plates hexagonal; arm spines, stout, blunt, four at base, three at middle of arm. Tentacle scale single, large, oval. Color (dried from alcohol). Disk, light grayish brown; arms, brown mottled with whitish, or clouded with purplish; oral surface lighter.

SPECIMENS OF OPHIONEREIS EURYBRACHYPLAX EXAMINED.—
Thirty-four.

Station	Locality	Depth, fathoms	Nature of bottom	Number of specimens
4535	Point Pinos Light House, N. 86° E., 3.7 miles.....	71-54	hard gray sand...	2
4552	Point Pinos Light House, S. 73° E., 4 miles.....	73-66	green mud, rock..	4
4553	Point Pinos Light House, S. 67° E., 3.7 miles.....	74-65	rock.....	6
4554	Point Pinos Light House, S. 76° E., 3 miles.....	60-80	green mud, rock..	20
4555	Point Pinos Light House, S. 63° E., 3.4 miles.....	66-69	green mud, rock..	2

Bathymetrical range, 54 to 80 fathoms.

Fig. 16. *Ophionereis* sp. (young), X11.—a, from below; b, from above; c, side view of two arm joints near disk.23. *Ophionereis* species, young

Disk, 3 mm. in diameter; arms about 8 mm. long; disk covered with about 280 coarse scales, some of which are larger than others; radial shields small, seed-shaped, scarcely larger than some of the disk-scales; widely separated by scales. Arms five, broad at base, narrowing to tip; upper arm plates at base of arm tetragonal, slightly wider than long, with rounded corners, broadly in contact; toward tip of arms they become triangular, with rounded corners, the apex of one plate barely, or at very tip of arms, not at all in contact with base of pre-

ceding plate. Interbrachial spaces below covered with coarse scales about the same size as those of disk. Oral shields low, triangular, with a concave base, and rounded angles, slightly wider than long. Adoral shields wider without than within. Oral papillæ four on each side, short, blunt; the outermost is the widest; teeth pointed, with rounded angles; no dental papillæ. Genital slits two in each interbrachial space, beginning at oral shield, narrow; they reach to about the middle of interbrachial spaces. First under arm plate small, squarish; succeeding plates at first octagonal, slightly longer than wide, becoming pentagonal toward tip of arms; barely or not in contact. Side arm plates large, barely meeting below, and on distal part of arm above; each plate carries three short, flat, subequal arm spines, about half as long as an arm joint. Tentacle scales single, large, oval.

Color in life. Aboral side of disk and arms mottled irregularly with light olive, white, and blackish brown. Oral side: Interbrachial spaces pinkish; arms white, with cross-bands of dark gray irregularly covering one to three plates, and spaced every one to three plates.

SPECIMEN EXAMINED.—Pacific Grove, low tide, under rock, sandy bottom; Aug. 4, 1921.

Dr. H. L. Clark determined this young form to be an *Ophionereis*. What species it belongs to is still problematical, since it was found too far north to be within the geographical range of *Ophionereis annulata* Le Conte, and being littoral, does not lie within the bathymetrical range of *Ophionereis eurybrachyplax* H. L. Clark.

Family VIII. OPHIOCOMIDÆ

Genus *Ophiopteris* Smith

Ophiopteris E. A. Smith, 1877, Ann. Mag. Hist., ser. 4, 19, p. 306.

Disk granulated; radial shields covered. Mouth angle small and short and with small oral papillæ; dental papillæ very numerous and arranged in a close, vertical clump; four teeth.

Arm spines smooth and solid, the upper one having one or two supplementary scale-like spines applied to its base; one tentacle scale. Two genital openings beginning outside the oral shield.

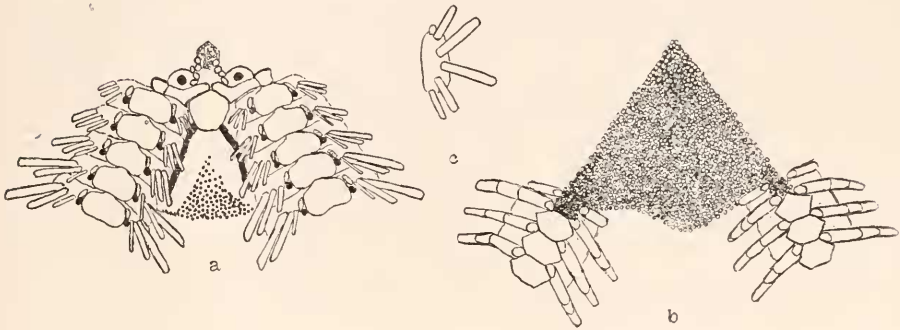


Fig. 17. *Ophiopteris papillosa*, X3.8.—a, from below; b, from above; c, side view of an arm joint near disk.

24. *Ophiopteris papillosa* (Lyman)

Ophiocoma papillosa Lyman, 1875, Illus. Cat., M. C. Z., No. 8, Pt. 2, p. 11.

Ophiopteris papillosa McClendon, 1909, Univ. Calif. Publ. Zool., 6, p. 49, pl. 5, f. 28, 29.

Diameters of disk ranging from 4 mm. to 30 mm.; disk completely covered with stumps. One flat tentacle scale. Dorsal arm plates hexagonal; arm spines flat and blunt.

Color in life. There is some variation. Aboral side of disk, blackish brown, bay, or dark brown; arms blackish brown, or coffee with cross bands of dark brown; or ochreous tawny, mars brown, lighter toward tips and crossed by blackish brown bands irregularly; or chestnut hazel at tips. Oral surface: Interbrachial spaces about same as disk; arms pecan brown; or hydrangea red crossed by light seal brown irregular bands, which are more conspicuous at tips of arms; or Indian red; middle of under arm plates yellowish marked with red and blue.

SPECIMENS OF OPHIOPTERIS PAPILLOSA EXAMINED.—Twenty-two.

Station 4531, Point Pinos Light House, N. 64° E., 2.1 miles, 26-28 fathoms, fine gray sand, pebbles, rock, 1 specimen.

Station 4558, Point Pinos Light House, N. 79° W., 2 miles, 40-28 fathoms, rock, 2 specimens.

Off Del Monte, 10-15 fathoms, 3 specimens.

Cypress Point, low tide, common in suitable spots.

Bathymetrical range, low tide to 40 fathoms.

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